[00048] What is claimed is:

[c001] An integrated disk type wheel hub motor/generator and electromagnetic braking method for aircraft landing gear comprising:

alternating rotor and stator disks such that a gap exist between said disks, each rotor disk is coupled to the wheel for rotation and wherein each stator disk is coupled to the axle and/or torque tube for support and electrically insulated from said support structure. The rotor disk stack maybe comprised of permanent magnets that generate an axial magnetic flux field, which are all orientated in the same magnetic orientation. The stator disk stack may be comprised of a pancake type disk design and electrical connections that are provided for by means such as conductive brushes or rolling contacts at the outer area of the stator disk and hard wired to the inner area of the disk thus providing for an electrical connection to an electrical source via an electronic switching and/or electromechanical control system to said electrically conductive stator disk thus providing a path for current flow, which are electrically insulated from the shaft such that each stator disk may generate an individual axial magnetic flux field, which may or may not act in the same vector direction as the other stator disk within said wheel hub motor/generator disk stack i.e. motor and/or generator action and/or motorized braking action. The method of motorized braking is accomplished by applying stored and/or generated onboard power and/or generated electrical power from one stator disk or disks to another stator disk or disks within the same, or other wheel hub motor/generator, disk stack in such a manner as to increase the braking

effect by applying power to another stator disk thus motoring the associated rotor disk such as to oppose the rotor rotational direction such that the other associated rotor disk or disks of said other stator disk or disks, thus accomplishing motorized braking or motoring of a disk or disks which is acting as a generator within the same or other wheel hub motor/generator disk stack as that of the generating disk or disks. The axial flux configuration allows for the incorporation of the wheel hub motor/generator in a disk stack directly within the hub of the landing gear wheels. In order to change the torque and/or speed of the wheel hub motor/generator the applied current source may be such that it is direct current, pulsed, alternating current or any combination thereof and/or by adjusting the air gap that exist between the stator and rotor sections of the wheel hub motor/generator thus allowing for adjustments to be made as to the torque and/or speed requirements within such an axial flux disk type motor/generator by means of incorporating the use of currently known actuation methods in order to produce the movement required of said disk thus producing such adjustments in the torque and/or speed of said wheel hub motor/generator.

[c002] An integrated disk type wheel hub motor/generator and electromagnetic braking method for aircraft landing gear comprising:

brushless design in which the use of rotors composed of permanent magnet segments such that there exist alternating north and south poles with the flux aligned axially. The stator section consists of stator coils attached to the stator disk, which is also segmented as such to align the coil sets with that of the permanent magnets used within the rotor. The stator coils require controlled

application of currents to said coils such as to cause motor action or may be used to supply electrical current by means of generator action depending upon the control electronics configuration and the associated electrical current path that is provided for by means of electrical connections and electronic switching controls. The electronic switching controls and electrical connections are such that an associated rotor stator disk set which are adjacent to each other act as a generator upon landing while another associated rotor stator disk set which are adjacent to each other act as a motor with the application of power from first said generator and/or external power source such as to aid the braking action present at the same instant in time thus providing a method of motorized braking within the wheel hub motor/generator disk stack which greatly increases the braking capacity of said electromagnetic brake system. Said brushless design incorporates the use of Hall effect sensors that are located near the stator coils in order to determine the position of the magnetic flux field of the permanent magnets in order to properly time the application of power to the stator coils when used for motoring and/or motorized braking.

[c003] As per claim 2 wherein:

each rotor disk magnet structure consist of a Halbach magnetic array segmented magnetic sections such that the orientation of the axial magnetic flux is such that the axial flux crosses one stator coil winding in one direction and then through the Halbach array such that the axial flux of the rotor disk crosses another stator coil winding in another region of the stator winding in the opposite direction. Within such an arrangement the stator coils are segmented into regions of coils that

coincide with the segmented regions of magnetic structure of the rotor sections, thus allowing for motor and/or generator and/or motorized braking of the wheel hub motor/generator as described in claim 2. The supplied current through a control system is such that the stator coil windings may be of a varying number of electrical phases via electrical connections such as to accomplish the motor and/or generator and/or motorized braking action within the wheel hub motor/generator.

[c004] As per claim 2 wherein:

electrical connections and electronic switching controls may be provided for such that all rotor and stator disks act as motors and/or generators individually, sequentially or in unison wherein the said electrical connections to each stator disk may be parallel and/or series. Applied current to the stator disk is in such a manner that allows for the wheel hub motor/generator providing for motor and/or generator action and/or motorized braking to the individual stator disk. Motor action is accomplished by means of a constant applied voltage or impulse or modulated voltage or any combination thereof. Generator action is accomplished by means of removing any applied voltage and thus allowing the relative motion of the permanent magnets within the rotors to generate an output voltage from the associated stator disk. The power generated may be dissipated through a resistor and/or stored and/or applied to another stator disk within the same, or other motor/generator, disk stack thus increasing the motor action present (i.e. braking action) within said other stator disk. Motorized braking action is accomplished by means of applying constant applied voltage or impulse or modulated voltage or any combination thereof to a stator disk, which is acting as a generator. This

method of motorized braking increases the motor action present within a stator disk that is acting as a generator and it this motor action, which generates the braking action within the method described as motorized braking. Altering the number of stator disk, which are connected electrically, and/or connection types i.e. parallel or series is controlled by an electrical means and can be accomplished dynamically as when shifting from motoring prior to touchdown to generating and/or motorized braking after touchdown of the aircraft. This provides for control over the magnitude of the motor and/or generator and/or motorized braking action thus controlling speed of the wheel hub motor/generator rotation. The main feature of the described electrical interconnection method proposed allows for an increase in braking capacity over those which incorporate the use of regenerative braking only, which has applications outside of landing gear in the area of electric vehicles such as trains, buses, trucks, cars, boats or other electrically driven devices which may require increased braking capacity which is provided for by the use of motorized braking as described within the present invention.

[c005] As per claim 1 wherein:

electrical connections and electronic switching controls may be provided for such that all rotor and stator disks act as motors and/or generators individually, sequentially or in unison wherein the said electrical connections to each stator disk may be parallel and/or series. Applied current to the stator disk is in such a manner that allows for the wheel hub motor/generator providing for motor and/or generator action and/or motorized braking to the individual stator disk. Motor

action is accomplished by means of a constant applied voltage or impulse or modulated voltage or any combination thereof. Generator action is accomplished by means of removing any applied voltage and thus allowing the relative motion of the permanent magnets within the rotors to generate an output voltage from the associated stator disk. The power generated may be dissipated through a resistor and/or stored and/or applied to another stator disk within the same, or other motor/generator, disk stack thus increasing the motor action present (i.e. braking action) within said other stator disk. Motorized braking action is accomplished by means of applying constant applied voltage or impulse or modulated voltage or any combination thereof to a stator disk, which is acting as a generator. This method of motorized braking increases the motor action present within a stator disk that is acting as a generator and it this motor action, which generates the braking action within the method described as motorized braking. Altering the number of stator disk, which are connected electrically, and/or connection types i.e. parallel or series is controlled by an electrical means and can be accomplished dynamically as when shifting from motoring prior to touchdown to generating and/or motorized braking after touchdown of the aircraft. This provides for control over the magnitude of the motor and/or generator and/or motorized braking action thus controlling speed of the wheel hub motor/generator rotation. The main feature of the described electrical interconnection method proposed allows for an increase in braking capacity over those which incorporate the use of regenerative braking only, which has applications outside of landing gear in the area of electric vehicles such as trains, buses, trucks, cars, boats or other

electrically driven devices which may require increased braking capacity which is provided for by the use of motorized braking as described within the present invention.

[c006] As per claim 1 wherein:

each rotor disk maybe an electrically conductive disk that may be constructed as the stator is within claim 1, which maybe provided an electrical current source using the same methods as stated for the stator disk in claim 1 in order to generate an axial magnetic flux field which will either produce motor and/or generator action wherein such action is used for braking and/or motoring and/or motorized-braking as described in claim 1 wherein the wheel hub motor/generator can provide motive force to the wheel on takeoff, thus aiding takeoff and decreasing the needed to brake on spin-up of the jet engines of the aircraft thus reducing the airframe stress and reducing the required runway distance required in order to achieve takeoff.

[c007] As per claim 1 wherein:

each rotor and/or stator disk are hollow in structure, which may or may not have at the outer rim vent fins for the purpose of providing for air flow and/or allowing air flow from the hollow shaft area to the outer rim of the stator disk to provide for air cooling of the wheel hub motor/generator.

[c008] As per claim 1 wherein:

each stator disk consist of an air gap coil or coils, which is structurally aligned with and coincides with the placement of the permanent magnets magnetic field within the rotor disk. The electrical currents supplied do not require any sliding or

rolling contacts within this variation, which is well known as a brushless design. Each rotor disk magnet structure consist of a Halbach magnetic array and/or segmented magnetic sections such that the orientation of the axial magnetic flux is such that the axial flux crosses one stator coil winding in one direction and then through the Halbach array and/or segmented magnetic sections are such that the axial flux of the rotor disk crosses another stator coil winding in another region of the stator winding in the opposite direction. Within such an arrangement the stator coils are segmented into regions of coils that coincide with the segmented regions of magnetic structure of the rotor sections, thus allowing for motor and/or generator and/or motorized braking of the wheel hub motor/generator. The supplied current through a control system is such that the stator coil windings may be of a varying number of electrical phases via electrical connections such as to accomplish the motor and/or generator and/or motorized braking action within the wheel hub motor/generator.

[c009] As per claim 1 wherein:

stored and/or generated onboard electrical power is used such that power is applied to the stator disk through provided electrical connections such that motor action is applied in the rotor disks in the opposite direction of rotation of the wheel rotation thus accomplishing motorized braking or motoring of a disk or disks within the wheel hub motor/generator.

[c010] An eddy current braking system as opposed to electromagnetic braking wherein:

the rotor disk are constructed of aluminum, aluminum alloy, steel, copper, beryllium, silver or any combination thereof and the stator disk maybe constructed as described above within claim 1 wherein the braking is accomplished by applying electrical current to the stator disk such that the magnetic field of the stator disk induces eddy currents within said rotor disk such that there is developed a magnetic torque which generates an eddy current braking action upon the wheel of said aircraft.

[c011] As per claim 1 wherein:

the combination of a electromagnetic braking system with that of a friction braking system is used within the landing gear, thus increasing the life time and aiding in the usefulness of the friction braking system by reducing the associated rate of wear of the friction disk within the friction braking system and reducing the required number of friction disk, thus reducing the maintenance cost.

[c0012] As per claim 10 wherein:

the combination of an eddy current braking system with that of a friction braking system is used within the landing gear, thus increasing the life time and aiding in the usefulness of the friction braking system by reducing the associated rate of wear of the friction disk within the friction braking system and reducing the required number of friction disk, thus reducing the maintenance cost.

[c0013] As per claim 1 wherein:

this method of motor/generator electrical interconnections of different stator disk or disks within the same, or other wheel hub motor/generator, disk stack or motorized braking method as proposed may be varied in numerous combinations

of generator disk or disks and motor disk or disks within the present invention and is unique in the area of disk type axial flux motor/generators and provides for flexibility by allowing for the electrical and/or physical addition of disk or disks or removal of disk or disks based upon the braking needs. This electrical interconnection of disk in which any disk within the wheel hub motor/generator disk stack may act as a motor or as a generator or in any combination thereof is known as motorized braking method thus adding flexibility to the design and use of braking systems. This proposed method of braking introduces flexibility in generating the required braking force that is lacking in the present state of the art in braking systems, which will allow for more efficient designs in that an overloaded aircraft can increase the amount of braking capacity by means of altering the electrical connections through controlled switching of applied power, thus increasing the safety of the aircraft.

[c0014] As per claim 1 wherein:

the generated electrical current from the stator disk may be dissipated through a resistor and/or stored on the airplane by means of battery, capacitor banks or other suitable electrical power storage device such as a gyro or toroidal coil that are electrically connected to the stator disk, through the implementation of control electronics and switches and/or physical contacts, thus allowing for storing of electrical power generated for the purpose of supplying electrical power for later use within the wheel hub motor/generator for the purpose of supplying power the individual disk of said wheel hub motor/generator as needed in the application of

motor and/or generator and/or motorized braking for later use in takeoff, landing, taxiing and ground maneuvers.

[c0015] As per claim 1 wherein:

implementing the use of disk type axial flux wheel hub motor/generators within the landing gear said aircraft is able to reduce the turn radius in which a 180-degree turn may be accomplished by means of motoring one set of landing gear in one direction and motoring the other set of landing gear in the opposite direction, this method of turning thus allows said aircraft to complete a 180-degree turn within a smaller turning radius as opposed to that of the current state of the art landing gear, due to the fact that the center of rotation of the present invention is located between the main landing gear on the center line of said aircraft and not at the intersection of the lines extending from the axes of the nose gear and landing gear as with current state of the art landing gear. This feature provides for reduced runway surface wear due to the lack of need to lock up the brakes on the pivoting landing gear assembly and eliminates the associated wear of the tires of the pivoting landing gear assembly due to the sliding friction, which is present in the current state of the art turning method used by said aircraft.

[c0016] As per claim 1 wherein:

in such an arrangement, the wheel hub motor/generator can provide motive force to the wheel when electrical power is applied to said wheel hub motor/generator, which may be applied prior to touchdown thus decreasing the difference in relative velocities of the tire radial velocity with that of the relative velocity of the landing surface thus greatly reducing the sliding friction wear of said tires

associated with the touchdown of the landing gear tires with the runway landing surface. After touchdown the wheel hub motor/generator may be used as a regenerative brake and/or motorized brake through the proper application and/or removal of applied power from stored and/or generated sources of power thus reducing the need for friction disk brakes.

[c0017]As per claim 11 wherein:

in order to change the torque and/or speed of the wheel hub motor/generator the applied current source may be such that it is direct current, pulsed, alternating current or any combination thereof and/or by adjusting the air gap that exist between the stator and rotor sections of the eddy current brake method thus allowing for adjustments to be made as to the torque and/or speed requirements within such an axial flux disk type eddy current brake by means of incorporating the use of currently known actuation methods in order to produce the movement required of said disk thus produce such adjustments in the torque and/or speed of the wheel.

[c0018] As per claim 1 wherein:

power supplied is from and external source of power via an attachment to the aircraft such as that used to propel or launch aircraft off an aircraft carrier. The means of electrical connection can be a direct physical contact connector or a non-contact type that employs the use of magnetic induction to transfer the energy from a ground track to the aircraft. In such an implementation ground tracks would be incorporated into the runway such as to allow for power transfer from a central ground facility power source or supply and provide for a means in which

aircraft control personnel could directly control ground movements of aircraft by remotely controlling the power supplied to the aircraft wheel hub motor/generator.

[c0019] As per claim 2 wherein:

electrical connections and electronic switching controls may be provided for such that all rotor and stator disks act as motors and/or generators individually, sequentially or in unison wherein the said electrical connections to each stator disk may be parallel and/or series. Applied current to the stator disk is in such a manner that allows for the wheel hub motor/generator providing for motor and/or generator action and/or motorized braking to the individual stator disk. Motor action is accomplished by means of a constant applied voltage or impulse or modulated voltage or any combination thereof. Generator action is accomplished by means of removing any applied voltage and thus allowing the relative motion of the permanent magnets within the rotors to generate an output voltage from the associated stator disk. The power generated may be dissipated through a resistor and/or stored and/or applied to another stator disk within the same, or other motor/generator, disk stack thus increasing the motor action present (i.e. braking action) within said other stator disk. Motorized braking action is accomplished by means of applying constant applied voltage or impulse or modulated voltage or any combination thereof to a stator disk, which is acting as a generator. This method of motorized braking increases the motor action present within a stator disk that is acting as a generator and it this motor action, which generates the braking action within the method described as motorized braking. Altering the

number of stator disk, which are connected electrically, and/or connection types i.e. parallel or series is controlled by an electrical means and can be accomplished dynamically as when shifting from motoring prior to touchdown to generating and/or motorized braking after touchdown of the aircraft. This provides for control over the magnitude of the motor and/or generator and/or motorized braking action thus controlling speed of the wheel hub motor/generator rotation. The main feature of the described electrical interconnection method proposed allows for an increase in braking capacity over those which incorporate the use of regenerative braking only, which has applications outside of landing gear in the area of electric vehicles such as trains, buses, trucks, cars, boats or other electrically driven devices which may require increased braking capacity which is provided for by the use of motorized braking as described within the present invention.

[c0020] As per claim 1 wherein:

the stator disks are of a flat printed disk construction, which are provided with electrical brush contacts.

[c021] As per claim 2 wherein:

the combination of a electromagnetic braking system with that of a friction braking system is used within the landing gear, thus increasing the life time and aiding in the usefulness of the friction braking system by reducing the associated rate of wear of the friction disk within the friction braking system and reducing the required number of friction disk, thus reducing the maintenance cost.